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K. F. WIBORG

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A.s John Griegs Boktrykkeri, Bergen

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INTRODUCTION.

In April and May 1947 some new gear for the collecting of zooplankton was tried in the West Fjord in Northern Norway by the staff of the Fisheries Directorate, Bergen, Norway.

We used the plankton sampler constructed by CLARKE and BUMPUS (CLARKE, G. L. and D. F. BUMPUS 1940), a centrifugal pump with a sucking hose, and the Nansen closing net, diameter at the opening 72 centimeters, bolting silk No. 8 in the lower cone, No. 0 in the upper cylindrical part.

The plankton sampler was placed at our disposal by professor dr. J. T. RUUD, the Biological Laboratory, Oslo.

METHODS OF SAMPLING.

The experimental hauls were made at two stations in the inner part of the West Fjord, the Austnes Fjord and the Økssund (fig. 1). The plankton sampler was used in horizontal hauls at different depths, and in oblique hauls. In the oblique hauls the sampler was raised either continually or in steps. At the end of the towing wire we used a weight of 30 kilogrammes. Above 50 meters of depth the sampler was towed with the towing wire at an angle of 30 degrees with the vertical, below 50 meters at 45 degrees. As a rule the sampler was towed for 5 minutes. The nets used in the sampler were of silk of numbers 2, 8 and 11. The volumes of water which passed through the sampler during a 5 minutes haul varied between 1500—2500 liters for net No. 2 and No. 8, and 400—1500 liters for net No. 11. The same series of hauls were made both with nets No. 2 and No. 11.

The plankton pump was an ordinary centrifugal pump, driven by the ships engine. It was provided with an one inch sucking hose of armed rubber, 38 meters long and yielding about 43 liters a minute. The capasity of the pump was found by measuring the time taken to fill a tank of a known volume. Usually 500 liters of water were pumped and filtered from each level.

Vertical hauls were made with the Nansen closing net for comparison with the sampler catches.

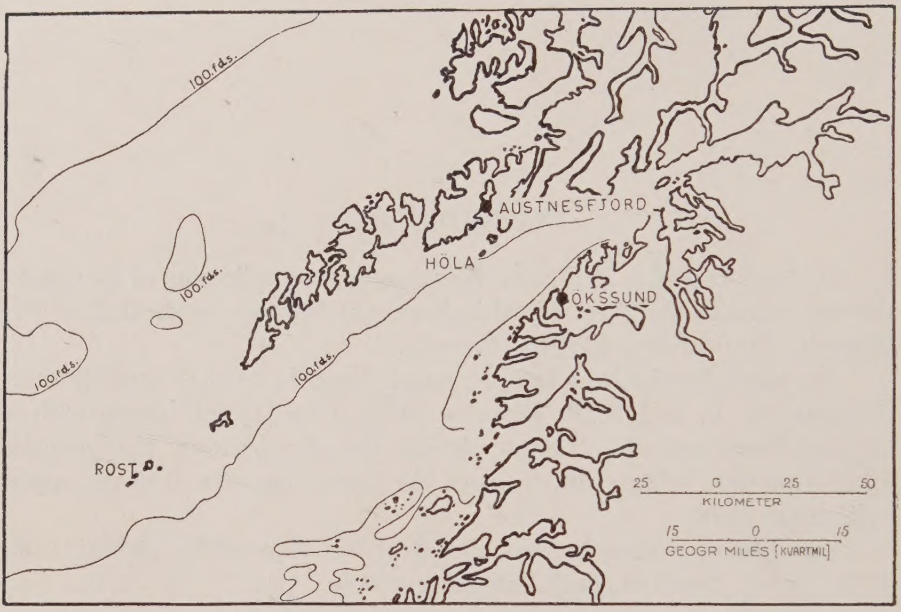

Fig. 1. Localities for the experiments with plankton pump and the Clarke-Bumpus plankton sampler in the Lofoten Area in April—May 1947.

MESH SIZE AND CATCHING POWER OF BOLTING SILK.

Before discussing the samples taken of the zooplankton it may be useful to mention the filtering power of the silk used in the plankton gear. It is not my intention to discuss the filtration coefficients of the different nets, only the mesh size.

The mesh sizes of the different numbers of plankton silk usually given, refer to new, dry silk cloth. But when the silk becomes wet, it will shrink and the mesh size will be diminished. Usually the nets have to be prepared with a preservative to avoid destruction by the sea water, and this will also diminish the mesh size.

In table 1 are given some measurements of the mesh sizes from wet bolting silk of different numbers and mesh sizes of dry silk of the corresponding numbers.

A long usage of the nets will diminish the meshes still more, and so will clogging of the net with plant or animal plankton.

In order to find out which organisms will be retained by plankton silk of a certain mesh size, I have measured the dimensions of some copepods and their larvae and eggs as shown in table 2 and fig. 3.

The measurements include total length, greatest diameter of body

TABLE 1.

Average aperture of the meshes of standard grade Dufour bolting silk.

Silk No.	Size of aperture, mm.	
	Dry silk	Wet silk
000	1.024	0.88—0.84
0	0.569	0.42
2	0.366	0.31—0.24
8	0.203	0.17—0.12
11	0.145	0.12—0.07
25	0.064	0.05

alone and of the body with legs and antennae laid in a natural position along its sides (fig. 2). It is assumed that some of the copepods will pass through the meshes of the net in this manner. The measurements are by no means exhaustive, as they include only copepods from one locality and one season of the year, but they will nevertheless give some information.

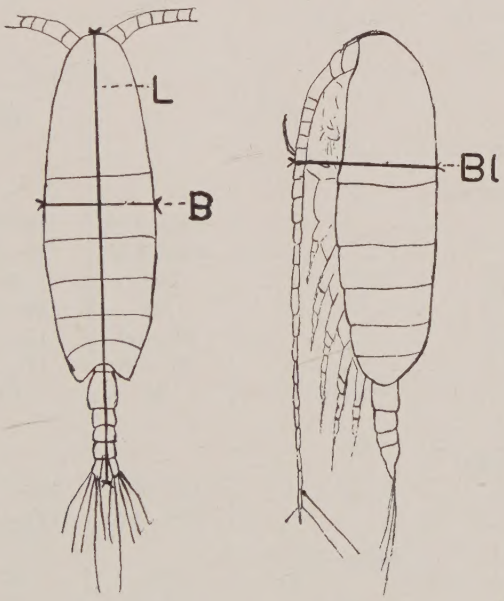

Fig. 2. The measurements taken in copepods in order to show how they may pass the meshes of a plankton net. L: total length, B: breadth with legs and antennae.

TABLE 2.

Measurements of the dimensions of copepods in 1/100 mm. L total length without spines. B greatest breadth of body. Bl breadth including antennae, legs and spines laid along the body.

Species	L	B	Bl
Calanus finmarchicus.			
♀	350—390	85—94	94—130
V	390	94	94—118
IV	242—279	67—79	64—88
III	184—233	42—57	61—71
II	127—131	28—33	45—47
I	90—100	24—29	31—36
N VI	57	24	33
N V	47	21	28
N IV	40	17	25
N III	31	14	21
N I—II	20	11	18
Eggs, diameter			14—16
Calanus hyperboreus			
♀	650	158	176
V	560	167	186
IV	409—419	108—95	118—119
III	279	76	95—105
II	150	40	60—78
I	114	36	43
N VI	82	33	43
N V, N IV, N III [1]			
N I—II	27	12	18
Eggs, diameter			24—28
Pseudocalanus minutus.			
♀	130—150	50—43	48—55
V	110—136	36—48	44—56
IV	105	29	38
III	83	24—26	31—36
II	60—69	12—19	17—24
I	57—60	17—19	23—24
N V—VI	36	19	24
Eggs, diameter			12—13
Pareuchaeta norvegica.			
V	539—558	140—186	251—270
IV	491—419	121—130	186
III			84
II	190	52	84
I	119	36	48
N VI	62	33	47
N III	50	31	50

[1] Of the same size as *C. finmarchicus*, N VI—IV.

Table 2 (Continued.)

Species	L	B	Bl
Acartia clausi			
♀	119	31	36
V	107	29	33
III	76	19	24
Microcalanus pusillus			
♂	83	26	33
♀	55—83	24—26	31—33
V	55	24	29
IV	43	14	19
III	32—36	13—14	19—21
II	26—29	12	14
I	21—24	10	12—14
Eggs, diameter			7.5—8.0
Metridia longa.			
♀			100
III	143	38	48
II	107	31	38
Metridia sp.			
I	67—71	20—26	26—31
N VI	46—56	21—26	31
N V	37—48	24	31
N IV	33—43	14—17	21—27
N III	19—23	10	15
Metridia lucens.			
♀	285	79	100
V	178—214	50—57	64—76
IV	162	40	56
Metridia eggs, diameter			17—20
Temora longicornis.			
♀	145	45	48
IV	74	26	27
N VI	41	—	12—14
Oithona helgolandica			
♀	67—98	19—24	19—24
V	86	21	21
IV	71	17	17
III	56	15	15
I	45	12	12
N VI	24—29	12	12
Oncaea borealis.			
♀	60	21	21
V	—	16—17	16—17
II	40	13	13
Microsetella norvegica.			
adults	48+setae	12	12
juv.		9	9
Evadne nordmanni	117	52	52
Thysanoessa inermis.			
nauplii	52	28	30
eggs, diameter			62

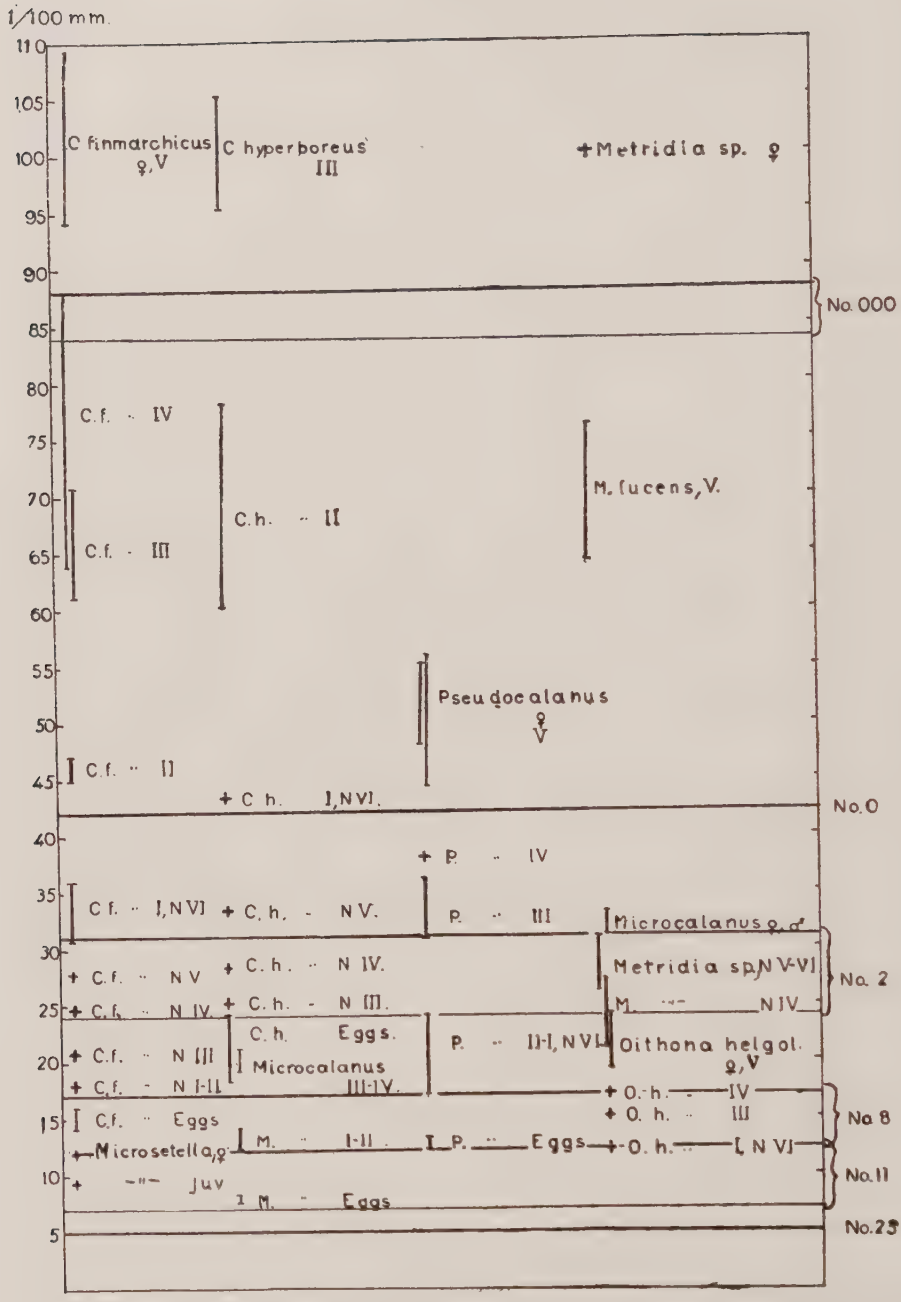

Fig. 3. A comparison between the mesh sizes of wet silk cloth of different numbers (horizontal lines) and the greatest breadth of some copepods and their larvae (vertical lines and crosses).

If we compare the greatest breadth of the copepods with the mesh sizes of wet plankton silk (fig. 3), we may get an impression as to which copepods are likely to be retained by plankton silk of different numbers. In case of varying mesh size, I refer to the largest mesh openings.

Silk No. 11 will retain most of the copepods, exept eggs and nauplii of *Microcalanus* and probably smaller nauplii of the *Oithona* sp.

Silk No. 8 will catch all stages of *Calanus hyperboreus* and *Calanus finmarchicus*, except the eggs and some of the nauplii of stage I—II of *C. finmarchicus*. Adults of *Oithona helgolandica*, *Microcalanus* from copepodite stage III and *Pseudocalanus* from nauplius stage IV will also be retained, while *Microsetella* easily passes through the meshes.

Silk No. 2 will catch all the *Calanus* copepodites, some of the nauplii of stage VI of *C. finmarchicus* and of stage V—VI of *C. hyperboreus*. *Pseudocalanus* and *Centropages hamatus* copepodites will be caught from stage III. Some adult *Microcalanus* will also be caught.

Silk No. 0 will retain *Calanus* copepodites from stage II, *Metridia longa* copepodites from stage III, *Pareuchaeta norvegica* from copepodite stage I, and adults of *Temora longicornis* and *Pseudocalanus*.

Silk No. 000 will catch adults and copepodites of stage V of *C. finmarchicus*, copepodites of *C. hyperboreus* from stage II, and adults of the *Metridia* spp.

It is to be stressed that the observations are few, and one cannot say *definitely* which copepods will be retained and which will pass through the meshes of a plankton net of a certain mesh size. Many copepods may possibly be able to press legs and antennae more close to the body than indicated by the measurements. On the other side, the length of the body as well as the antennae and legs when they are extended, will help to catch more of the smaller specimens.

In other waters and at other times of the year the dimensions of the same copepods may be somewhat different.

THE EXPERIMENTAL HAULS.

Table I (page 24) shows the number of copepods and other plankton organisms caught by the plankton sampler and the Nansen net in the Austnes Fjord on April 23. As the sampler failed to close after the hauls at the 10 and 25 meter levels, these hauls must be regarded with some precaution.

In order to show the difference in catching power of nets equipped with plankton silk No.s 2 and 11 *Calanus finmarchicus* has been divided into copepodites, and nauplii and eggs, and the other copepods have

been divided into those bigger and those smaller than nauplius stage VI of *C. finmarchicus* (table 3).

As one would expect a greater quantity of *Calanus* nauplii and smaller copepods are caught in the *11* net than in the *2* net. The latter caught a somewhat greater number of bigger copepods and of larvae of fishes, decapods and euphausiids.

Table 4 (page 14) shows the number of plankton organisms taken with the same gear in the Austnes Fjord on May 30. At this station oblique hauls were made with the sampler raised in steps. There is no marked difference between the number of bigger organisms taken with the *2* and *11* nets (see also Table II, page 26).

It is worth noting that the proportion of copepodites and adults compared with nauplii and eggs of *C. finmarchius* is much greater in the Nansen net hauls than in the hauls with the plankton sampler in the same depths. As shown above, the *8* net will not catch the eggs of *C. finmarchicus* quantitatively, neither the smallest nauplii. A great deal of the smaller copepodites and nauplii of *Oithona* sp. will also escape through the meshes. The construction of the Nansen net with the upper cylindrical part provided with silk No. 0 and the lower cone with silk No. 8 will further help to catch more of the bigger copepodites. In fig. 4 is shown the stage distribution of *Calanus finmarchicus*, as it occurs in the hauls with Nansen net 8/72, and in the plankton sampler hauls with silk nets No. 2 and 11. They all differ from each other.

On May 2. experiments were made with the pump. Samples of 500 liters were pumped from different levels from 1—38 meters and filtered. From the same depths samples were taken with the plankton sampler. Silk net No. 11 was used both for the pump and for the sampler. During the haul at the 5 meter level the net was lost. The number of organisms caught is shown in table 5, (page 17) and table III (page 28).

With one exception, at the 15 meter level, a smaller number of organisms was caught per 1000 liters of sea water in the pump collections than in the hauls with the sampler. There was no essential difference in the distribution of stage of *C. finmarchicus* in the pump and sampler collections, but a somewhat greater number of *Oithona* was taken by the pump. In return, a greater number of the bigger copepods was caught in the sampler hauls, and also a greater number of fish larvae and decapods.

After the net made of silk No. 11 had been lost, a new net had to be made by the material available, silk No. 8.

At the station in the Økssund (table 6 page 18, and table IV page 30) the plankton sampler was tried in deeper water. A series of hauls was made at different levels from 1—425 meters of depth. Oblique hauls

TABLE 3.

Zooplankton collected with Clarke's plankton sampler, silk net No. 2 and 11, and with Nansen closing net, silk No. 8 Austnes Fjord April 23. 1947. Number of organisms per 1000 liters of sea water.

Depth, meters	5		10		25		50		75		25—0	50-25	75-50	125-75
Volume filtered, liters	3 284	776	1 804	828	1 876	324	1 860	912	1 684	892				
Species / Gear	PS 2	PS 11[1]	PS 2[1]	PS 11[1]	PS 2[1]	PS 11	PS 2	PS 11	PS 2	PS 11	8/72	8/72	8/72	8/72
Calanus finmarchicus adults and copepodites	5 675	1 297	5 612	2 217	2 234	3 059	151	133	82	16	4 025	3 033	220	56
nauplii and eggs	973	10 933	889	7 303	5 474	17 750	27	1 828	3	707	4 200	3 700	30	180
Oithona spp. adults and larvae	—	—	—	—	27	6 319	19	457	36	191	200	58	220	40
Other copepods: Bigger than *C. finmarchicus* nauplius stage VI (A)	1 039	623	1 174	432	1 826	1 334	10	12	29	22	2 726	560	25	99
Smaller than *C. finmarchicus*, nauplius stage VI (B)	160	526	84	300	27	950	6	328	17	92	550	8	120	125
Total copepods	7 847	13 379	7 759	10 252	9 588	29 412	213	2 758	167	1 028	11 701	7359	615	500
Decapod larvae	1	—	6	11	265	37	15	28	6	1	10	58	43	10
Euphausiid calyptopis	35	32	28	13	27	25	1	—	3	—	—	8	5	—
E. nauplii and eggs	5	21	2 639	15	508	333	11	27	—	2	600	400	50	20
Fish larvae	1	—	17	5	10	12	—	—	—	—	5	3	—	—
Fish eggs	45	49	102	22	57	15	7	1	2	—	244	19	7	—
Other organisms	939	1 012	1 611	1 188	537	925	27	64	2	35	908	375	11	37
Total organisms	8 873	14 493	12 162	11 506	10 992	30 759	274	2 878	180	1 066	13 468	8 222	731	567

[1] Not closed.

TABLE 4.

Zooplankton collected with Clarke's plankton sampler, silk net No. 2
Number of organisms per

Depth, meters	10		25		30	50
Volume filtered, liters	2 324	1 404	1 912	1 008	756	2 160
Species / Gear	PS 2	PS 11	PS 2	PS 11	PS 11	PS 2
Calanus finmarchicus						
adults and copepodites	3 993	5 492	1 694	1 933	882	447
nauplii and eggs	43	8 968	157	9 800	11 720	162
Oithona spp. adults and larvae	128	1 998	104	4 400	1 452	42
Other copepods.						
Bigger than *C. finmarchicus*, nauplius stage VI (A)	699	321	867	633	394	140
Smaller than *C. finmarchicus*, nauplius stage VI (B)	85	855	52	600	339	28
Total copepods	4 948	17 634	2 874	17 366	14 787	819
Decapod larvae	14	6	47	57	41	29
Euphausiid calyptopis	149	36	105	33	33	42
E. nauplii and eggs	—	—	30	67	11	5
Fish larvae	24	11	1	3	1	1
Fish eggs	31	17	12	11	8	9
Other organisms	67	386	270	304	594	37
Total organisms	5 233	18 090	3 339	17 841	15 475	943

were also made. At the corresponding depth intervals vertical hauls were made with the Nansen net.

In fig. 5 (page 16) is shown the percentage distribution of the different stages of *Calanus finmarchicus* in the sampler and Nansen net hauls. Comparatively more copepodites and adults are caught in the Nansen net than with the plankton sampler.

and 11, and with Nansen closing net, silk No. 8. Austnes Fjord April 30. 1947. 1000 liters of sea water.

60		100		25—0			60—25			100—60		
1 704	872	737	764	2 504	1 680		2 412	1 044		1 360	2 716	
PS 2	PS 11	PS 2	PS 11	PS 2	PS 11	8/72	PS 2	PS 11	8/72	PS 2	PS 11	8/72
206	701	82	57	6 560	6 584	44 783	1 198	983	3 941	65	76	2 483
53	1 777	61	793	480	10 350	13 500	187	2 450	10 300	117	514	4 200
21	518	48	281	120	2 558	3 900	—	800	1 100	59	137	1 500
108	156	23	43	455	822	2 726	244	333	1 485	132	31	1 041
39	359	34	203	40	329	1 200	42	258	550	80	206	1 808
427	3 511	248	1 377	7 655	20 643	66 109	1 671	4 824	17 376	453	964	11 032
17	17	—	1	58	25	27	39	37	44	13	1	30
50	41	—	—	10	30	500	38	25	300	22	10	83
9	23	—	—	40	30	100	42	67	50	37	1	17
1	2	—	1	13	11	21	1	—	6	4	2	7
11	6	—	—	10	19	54	7	6	36	7	2	5
33	423	—	38	187	160	758	—	411	1 159	37	93	35
548	4 023	248	1 417	7 973	20 918	67 569	1 798	5 370	18 971	573	1 073	11 209

At the end of June 1947 I had the opportunity to follow professor dr. J. T. Ruud on a short cruise with the research vessel »Gunnar Knudsen" in the Oslo Fjord. We then tried a series of 3 and 4 plankton samplers attached to the same wire. The samplers all worked satisfactorily, opened and closed in succession.

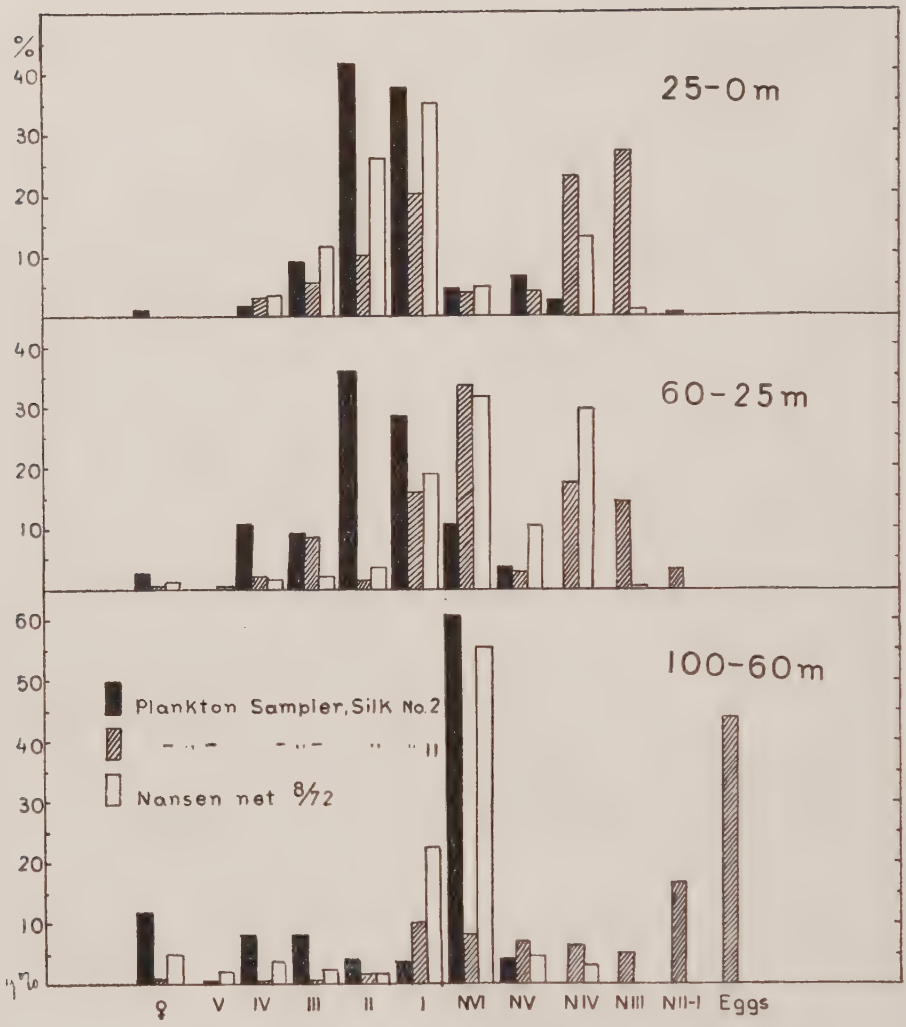

Fig. 4. The stage distribution of *Calanus finmarchicus* in vertical hauls with Nansen net, silk No. 0—8 and in oblique hauls in the same depths with plankton sampler, silk No. 2 and 11. Austnes Fjord, April 30th 1947.

TABLE 5.

Zooplankton collected with Clarke's plankton sampler and with pump, both with silk net No. 11.
Austnes fjord May 2. 1947. Number of organisms per 1000 liters of sea water.

Depth, meters	1	5	10		15		20		25		30		38	
Volume filtered, liters	500	500	500	996	500	712	500	824	500	788	500	824	500	646
Species / Gear	Pump	Pump	Pump	PS 11	Pump	PS 11	Pump	PS 11	Pump	PS 11	Pump	PS 11	Pump	PS 11
Calanus finmarchicus adults and copepodites	2 016	2 590	3 000	5 724	6 020	7 023	4 668	6 229	2 584	3 641	784	3 701	1 182	1 275
nauplii and eggs	8 900	5 600	2 800	5 200	3 600	2 320	1 700	4 251	3 700	6 974	7 300	22 260	7 770	8 140
Oithona spp., adults and larvae	—	100	400	400	932	562	816	425	1 400	381	2 100	3 340	2 280	2 325
Other copepods. Bigger than *C. finmarchicus*, nauplius stage VI (A)	214	550	130	350	126	212	148	433	172	222	130	230	190	463
Smaller than *C. finmarchicus*, nauplius stage VI (B)	16	216	416	158	248	11	200	424	300	508	400	80	330	465
Total copepods	11 146	9 056	6 746	11 832	10 926	10 128	7 532	11 762	8 156	11 726	10 714	29 611	11 752	12 668
Decapod larvae	—	2	—	2	6	15	8	11	8	23	4	30	2	28
Euphausiid calyptopis	—	66	8	58	16	82	2	80	—	10	—	33	10	39
E. nauplii and eggs	—	—	—	—	—	—	—	10	—	10	—	29	10	—
Fish larvae	2	—	12	17	2	14	2	23	2	4	—	12	—	3
Fish eggs	2	—	6	8	2	13	6	16	6	17	8	7	—	9
Other organisms	400	100	32	886	84	503	372	263	100	380	—	740	130	182
Total organisms	11 550	9 224	6 804	12 803	11 036	10 755	7 922	12 165	8 272	12 170	10 726	30 462	11 904	12 929

TABLE 6.

Zooplankton collected with Clarke's plankton sampler and with
Number of organisms per

Depth, meters	1	10	25	50
Volume filtered, liters	2 784	2 112	1 832	1 248
Species / Gear	PS 8	PS 8	PS 8	PS 8
Calanus finmarchicus				
adults and copepodites	1 674	2 914	3 308	98
nauplii and eggs	6 511	1 420	6 455	496
Oithona spp. adults and larvae	—	—	546	259
Other copepods:				
Bigger than *C. finmarchicus*, nauplius stage VI (A)	271	416	550	41
Smaller than C. *finmarchicus*, nauplius stage VI (B)	363	106	113	262
Total copepods	8 819	4 856	10 972	1 156
Decapod larvae	—	1	2	—
Euphausiid calyptopis	—	9	300	22
E. nauplii and eggs	—	4	218	36
Fish larvae	—	3	43	1
Fish eggs	8	5	3	—
Other organisms	308	620	1 008	137
Total organisms	9 135	5 498	12 546	1 352

Nansen closing net, both with silk net No. 8. Økssund May 3. 1947.
1000 liters of sea water.

100	150	425	25—0		50—25		100—50		150—100		450—150	
384	564	828	2 120		944		940		864		2 136	
PS 8	PS 8	PS 8	PS 8	8/72	PS 8	8/72	PS 8	8/72	PS 8	8/72	PS 8	8/72
83	29	25	4 188	21 183	306	2 216	117	194	46	138	4	90
146	79	22	4 303	6 900	4 769	4 600	214	60	122	25	22	—
16	4	4	94	17	436	100	133	80	9	10	2	—
13	6	27	203	922	54	124	28	43	9	124	25	923
138	33	63	189	—	266	308	59	345	155	200	29	893
396	151	141	8 977	29 022	5 830	7 348	551	722	341	497	82	1 906
—	—	—	1	1	1	3	—	—	1	—	—	7
3	4	1	—	350	38	16	3	30	—	30	1	—
—	—	2	—	150	96	16	27	30	1	—	1	20
—	—	—	7	15	20	2	—	3	2	1	—	2
—	—	—	12	9	—	—	11	—	5	—	—	—
3	9	11	578	1 417	678	301	145	115	14	27	17	603
402	164	155	9 575	30 964	6 663	7 686	737	900	364	555	101	2 538

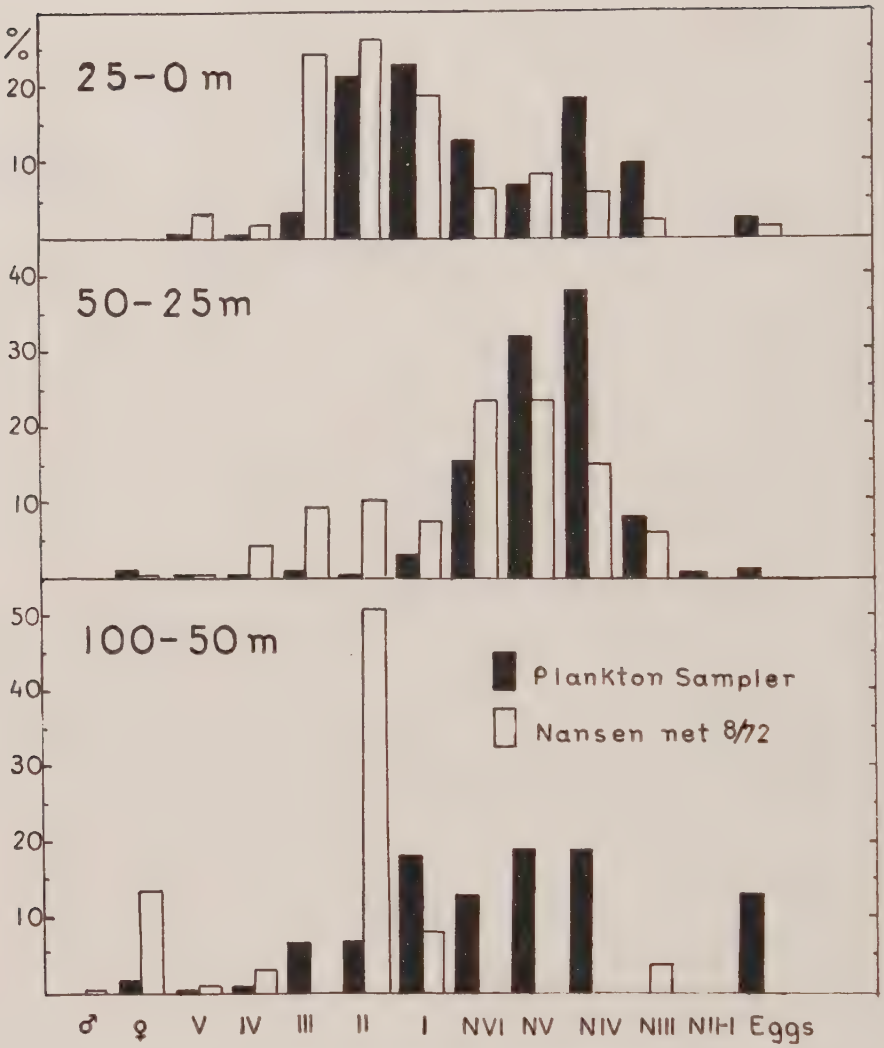

Fig. 5. The stage distribution of *Calanus finmarchicus* in vertical hauls with Nansen net, silk No. 0—8 and in oblique hauls in the same depths with plankton sampler, silk No. 8. Økssund, May 3rd. 1947.

DISCUSSION.

The plankton sampler constructed by Clarke and Bumpus is an apparatus well suited for the collection of quantitative samples of zooplankton. It has proved very satisfactory for the investigation of cod larvae and their food organisms in the upper 100 meters in the Lofoten Area in Northern Norway. — It has also proved suitable for the investigation of chaetognaths (Clarke, Pierce and Bumpus 1943).

With the plankton sampler one can obtain samples of zooplankton from a certain level of the sea, as well as samples from the whole column of water from bottom to surface, except from the water layers 5—10 meters near the bottom. Different water layers can be investigated simultaneously. The samples can be referred to a definite volume of water, and there is no essential error caused by change in the filtration coefficient of the same net. In case of heavy clogging (not met with in our experiments) there will be a considerable error, which, however, will be met with in all kinds of plankton nets. In such a case, the pump probably will give the most reliable results.

There seems to be no great difference between the catches of the bigger copepods in the net with silk No. 2, and those in the *11* net, and one may assume that the *11* net will give a quite reliable picture of the whole copepod population. The *8* net will lose a great deal of the eggs and smallest nauplii of *Calanus finmarchicus* as well as the copepodites and nauplii of *Oithona* spp. and of *Microsetella*.

The pump method has been discussed to a great extent by previous scientists, and Gibbons and Fraser (1937) have made experiments with a centrifugal pump with suction hose. Fraser has later in a short report to the International Counsil (1947) given further informations of the last improvements of the method.

The pump used in the Lofoten Area in 1947 had too small capasity. As stated by Fraser (1947) one must assume that faster moving organisms will succeed in avoiding the water current at the mouth of the sucking hose. It will also take too long time to pump a quantity of water sufficient large to give a reliable result. An amount of at least 200 liters a minute is required.

The pump is more difficult to handle than the plankton sampler,

and it is also difficult to obtain samples from the whole column of sea water from bottom to surface.

The Nansen net 8/72 has been used for long time in the Norwegian plankton investigations. It is easy to handle, but the drawback with this net and also with most part of the other not-measuring nets used, is that the filtering capasity is not constant, but will vary according to the speed of the hauling, the quantity and quality of the plankton, and the age of the net. It is thus impossible to give the actual number of organisms per volume unit of sea water.

With pump and vertical net hauls one will obtain the samples of each station from a very restricted area which may give way to errors caused by local swarming or absence of the organisms. This error will to a certain degree be avoided in hauls with the Clarke-Bumpus plankton sampler.

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TABLE I.

Zooplankton collected with Clarke's plankton sampler, silk net No. 2
Number of organisms per

Depth, meters	5		10		25	
Volume filtered, liters	3 284	776[1]	1 804[1]	828[1]	1 876	324
Species / Gear	PS 2	PS 11	PS 2	PS 11	PS 2	PS 11
Calanus finmarchicus:						
♂	15	—	—	—	4	25
♀	25	17	23	—	18	52
V	2	10	—	—	4	—
IV	212	43	139	40	18	52
III	823	—	750	242	350	308
II	2 498	387	1 030	665	800	772
I	2 100	840	3 670	1 270	1 040	1 850
Total copepodites and adults	5 675	1 297	5 612	2 217	2 234	3 059
N VI	791	1 420	610	965	5 340	2 010
N V	91	902	167	1 030	107	2 470
N IV	61	2 425	56	965	27	2 160
N III	30	4 640	56	3 620	—	7 400
N II—I	—	516	—	120	—	3 710
Eggs	—	1 030	—	603	—	—
Total nauplii and eggs	973	10 933	889	7 303	5 474	17 750
Total *Calanus finmarchicus*	6 648	12 230	6 501	9 520	7 708	20 809
Calanus hyperboreus:						
♀	2	—	4	1	534	25
V	1	10	—	1	3	—
IV	84	65	306	130	292	488
III	46	32	167	120	240	642
II	30	—	56	—	534	25
I	152	322	222	—	80	154
Total copepodites and adults	315	429	755	252	1 683	1 334
N VI	700	129	334	120	134	—
N V	122	129	—	—	27	—
N IV	—	—	—	—	—	—
N III	—	—	—	—	—	—
Total nauplii	822	258	334	120	161	—
Total *Calanus hyperboreus*	1 137	687	1 089	372	1 844	1 334
Oithona spp. adults a. larvae	—	—	—	—	27	6 319
Microsetella norvegica	—	129	—	60	—	617
Other copepods	62	333	169	300	9	333
Total copepods	7 847	13 379	7 759	10 252	9 588	29 412
Decapod larvae	1	—	6	11	265	37
Euphausiid calyptopis	35	32	28	13	27	25
E. nauplii and eggs	5	21	2 639	15	508	333
Fish larvae	1	—	17	5	10	12
Fish eggs	45	49	102	22	57	15
Other organisms	939	1 012	1 611	1 188	537	925
Total organisms	8 873	14 493	12 162	11 506	10 992	30 759

[1] Failed to close.

and 11, and with Nansen closing net, silk No. 8. Austnes Fjord April 23. 1947. 1000 liters of sea water.

50		75		25—0	50—25	75—50	125—75
1 860	912	892	1 684				
PS 2	PS 11	PS 11	PS 2	8/72	8/72	8/72	8/72
3	—	—	—	—	—	15	—
75	24	3	2	25	33	60	6
3	9	—	—	—	—	10	—
8	9	1	9	250	50	5	10
24	27	5	11	1 050	400	20	20
19	55	7	18	1 200	700	35	15
19	9	—	42	1 500	1 850	75	5
151	133	16	82	4 025	3 033	220	56
24	18	22	—	1 500	700	10	80
—	36	11	—	800	1 500	—	30
3	18	34	3	700	1 100	—	10
—	387	79	—	1 200	300	20	—
—	988	56	—	—	—	—	—
—	384	505	—	—	100	—	60
27	1 828	707	3	4 200	3 700	30	180
178	1 961	723	85	8 225	6 733	250	236
—	—	—	—	1	1	—	1
—	—	1	1	25	1	—	5
5	6	3	4	1 200	300	15	35
5	4	2	2	1 100	200	—	5
—	—	—	—	150	—	—	—
—	—	2	3	—	—	—	15
10	12	8	10	1 976	502	15	61
—	—	1	9	700	50	—	20
3	9	—	—	200	—	—	5
—	—	—	3	—	—	—	—
—	—	—	—	200	—	—	—
3	9	1	12	1 100	50	—	25
13	21	9	22	3 076	552	15	86
19	457	191	36	200	58	220	40
—	220	28	—	—	—	—	—
3	99	77	24	200	16	130	138
213	2 758	1 028	167	11 701	7 359	615	500
15	28	1	6	10	58	43	10
1	—	—	3	—	8	5	—
11	27	2	—	600	400	50	20
—	—	—	—	5	3	—	—
7	1	—	2	244	19	7	—
27	64	35	2	908	375	11	37
274	2 878	1 066	180	13 468	8 222	731	567

TABLE II.

Zooplankton collected with Clarke's plankton sampler, silk net No. 2 and 11, Number of organisms per

Depth, meters	10		25		30	50
Volume filtered, liters	2 324	1 404	1 912	1 008	756	2 160
Species / Gear	PS 2	PS 11	PS 2	PS 11	PS 11	PS 2
Calanus finmarchicus:						
♂	—	—	4	—	—	—
♀	11	—	9	75	11	21
V	—	36	9	8	11	2
IV	149	36	105	200	66	19
III	298	570	340	—	—	60
II	1 490	1 570	392	350	132	42
I	2 045	3 280	835	1 300	662	303
Total copepodites and adults	3 993	5 492	1 694	1 933	882	447
N VI	—	855	157	1 300	2 620	134
N V	43	570	—	3 500	2 250	5
N IV	—	3 700	—	3 800	2 620	14
N III	—	3 700	—	800	4 230	9
N II—I	—	143	—	100	—	—
Eggs	—	—	—	300	—	—
Total nauplii and eggs	43	8 968	157	9 800	11 720	162
Total *Calanus finmarchicus*	4 036	14 460	1 851	11 733	12 602	609
Calanus hyperboreus:						
♀	1	—	—	—	1	—
V	61	30	35	33	16	21
IV	298	190	420	200	122	58
III	21	—	52	50	23	7
II	64	—	314	200	66	14
I	85	71	29	50	—	19
Total copepodites and adults	529	291	850	533	228	119
N VI	—	—	—	—	66	—
N V	—	—	52	—	—	—
N IV	—	—	—	—	—	—
N III	—	—	—	—	—	—
Total nauplii	—	—	52	—	66	—
Total *Calanus hyperboreus*	529	291	902	533	394	119
Oithona spp. adults and larvae	128	1 998	104	4 400	1 452	42
Microsetella norvegica	—	—	—	100	66	—
Other copepods	255	885	17	600	273	49
Total copepods	4 948	17 634	2 874	17 366	14 787	819
Decapod larvae	14	6	47	57	41	29
Euphausiid calyptopis	149	36	105	33	33	42
E. nauplii and eggs	—	—	30	67	11	5
Fish larvae	24	11	1	3	1	1
Fish eggs	31	17	12	11	8	9
Other organisms	67	386	270	304	594	37
Total organisms	5 233	18 090	3 339	17 841	15 475	943

and with Nansen closing net, silk No. 8. Austnes Fjord April 30. 1947.
1000 liters of sea water.

60		100		25—0			60—25			100—60		
1 704	872	737	764	2 504	1 680		2 412	1 044		1 360	2 716	
PS 2	PS 11	PS 2	PS 11	PS 2	PS 11	8/72	PS 2	PS 11	8/72	PS 2	PS 11	8/72
3	6	—	—	—	—	—	—	—	8	—	—	8
23	34	11	11	60	30	83	34	8	133	22	5	325
9	—	3	—	20	—	150	—	—	100	—	1	150
15	—	—	—	120	536	2 000	145	75	200	15	4	250
3	—	—	—	640	893	6 700	124	300	300	15	—	150
6	6	34	20	3 080	1 725	15 400	500	50	500	7	9	100
147	655	34	26	2 640	3 400	20 500	395	550	2 700	6	57	1 500
206	701	82	57	6 560	6 584	44 783	1 198	983	3 941	65	76	2 483
53	675	34	66	320	655	2 900	145	1 150	4 500	110	48	3 700
—	126	27	66	—	1 130	2 400	42	100	1 500	7	41	300
—	298	—	111	160	3 925	7 700	—	600	4 200	—	37	200
—	138	—	13	—	4 580	500	—	500	100	—	30	—
—	23	—	157	—	60	—	—	100	—	—	96	—
—	516	—	380	—	—	—	—	—	—	—	262	—
53	1 777	61	793	480	10 350	13 500	187	2 450	10 300	117	514	4 200
259	2 478	143	850	7 040	16 934	58 283	1 385	3 433	14 241	182	590	6 683
—	—	—	—	—	1	1	2	—	2	2	—	2
3	—	1	—	5	35	100	27	25	83	4	2	83
53	57	15	27	440	328	467	145	258	1 050	70	12	500
18	6	3	4	—	60	8	—	—	50	15	2	100
—	12	—	—	—	238	1 000	—	50	50	—	2	50
—	12	—	—	—	60	700	42	—	50	7	—	—
74	87	19	31	445	722	2 276	216	333	1 285	98	18	735
—	34	—	—	—	—	—	—	—	50	—	—	250
—	12	7	—	—	—	—	—	—	50	7	—	100
—	12	7	—	—	—	—	—	—	50	—	—	—
—	—	—	—	—	—	—	—	—	—	—	—	—
—	58	14	—	—	—	—	—	—	150	7	—	350
74	145	33	31	445	722	2 276	216	333	1 435	105	18	1 085
21	518	48	281	120	2 558	3 900	—	800	1 100	59	137	1 500
—	138	—	13	—	30	—	—	100	—	—	41	—
73	232	24	202	50	399	1 650	70	158	600	107	178	1 764
427	3 511	248	1 377	7 655	20 643	66 109	1 671	4 824	17 376	453	964	11 032
17	17	—	1	58	25	27	39	37	44	13	1	30
50	41	—	—	10	30	500	38	25	300	22	10	83
9	23	—	—	40	30	100	42	67	50	37	1	17
1	2	—	1	13	11	21	1	—	6	4	2	7
11	6	—	—	10	19	54	7	6	36	7	2	5
33	423	—	38	187	160	758	—	411	1 159	37	93	35
548	4 023	248	1 417	7 973	20 918	67 569	1 798	5 370	18 971	573	1 073	11 209

TABLE III.

Zooplankton collected with pump and with Clarke's plankton sampler, silk net No. 11.

Depth, meters	1	5	10		15	
Volume filtered, liters						
Species / Gear	Pump	Pump	Pump	PS 11	Pump	PS 11
Calanus finmarchicus:						
♂	—	—	—	—	—	—
♀	—	6	—	8	4	1
V	—	16	—	—	—	11
IV	50	84	100	66	150	59
III	266	284	400	1 050	666	632
II	400	500	600	2 100	2 700	1 690
I	1 300	1 700	1 900	2 500	2 500	4 630
Total copepodites and adults	2 016	2 590	3 000	5 724	6 020	7 023
N VI	1 500	800	300	400	400	492
N V	800	900	700	1 000	300	351
N IV	2 600	1 000	1 100	1 500	800	492
N III	3 600	2 300	600	2 000	1 800	985
N II—I	400	—	100	300	300	—
Eggs	—	—	—	—	—	—
Total nauplii and eggs	8 900	5 600	2 800	5 200	3 600	2 320
Total *Calanus finmarchicus*	10 916	8 190	5 800	10 924	9 620	9 343
Calanus hyperboreus:						
♀	—	—	—	—	—	1
V	16	84	30	42	10	13
IV	150	366	84	100	116	128
III	16	—	—	100	—	—
II	32	100	—	50	—	—
I	—	—	—	50	—	—
Total copepodites and adults	214	550	114	342	126	142
N VI	—	—	16	—	—	—
N V	—	—	—	50	—	—
N IV	—	—	—	—	—	—
N III	—	—	—	—	—	—
Total nauplii	—	—	16	50	—	—
Total *Calanus hyperboreus*	214	550	130	392	126	142
Oithona spp. adults a. larvae	—	100	400	400	932	562
Microsetella norvegica	—	—	16	50	100	
Other copepods	16	216	400	66	148	81
Total copepods	11 146	9 056	6 746	11 832	10 926	10 128
Decapod larvae	—	2	—	2	6	15
Euphausiid calyptopis	—	66	8	58	16	82
E. nauplii and eggs	—	—	—	—	—	—
Fish larvae	2	—	12	17	2	14
Fish eggs	2	—	6	8	2	13
Other organisms	400	100	32	886	84	503
Total organisms	11 550	9 224	6 804	12 803	11 036	10 755

Austnes Fjord, May 2. 1947. Number of organisms per 1000 liters of sea water.

20		25		30		38	
Pump	PS 11	Pump	PS 11	Pump	PS 11	Pump	PS 11
—	—	2	—	—	—	—	—
2	19	—	10	—	50	2	11
16	—	—	20	—	19	—	—
66	80	16	117	50	100	10	51
484	730	266	64	150	607	60	128
1 300	2 060	300	760	184	495	90	155
2 800	3 340	2 000	2 670	400	2 430	1 020	930
4 668	6 229	2 584	3 641	784	3 701	1 182	1 275
—	607	200	1 080	1 200	3 640	1 790	1 640
—	364	800	760	600	3 800	2 000	2 630
300	1 340	1 100	3 040	1 900	7 520	2 100	1 550
1 400	1 940	1 600	2 030	3 600	7 300	1 800	1 700
—	—	—	64	—	—	60	620
—	—	—	—	—	—	20	—
1 700	4 251	3 700	6 974	7 300	22 260	7 770	8 140
6 368	10 480	6 284	10 615	8 084	25 961	8 952	9 415
2	—	—	—	—	—	—	—
10	70	8	41	16	30	30	51
36	192	66	149	50	160	120	206
—	50	—	32	32	10	—	39
100	—	32	—	32	—	—	—
—	—	50	—	—	—	—	—
148	312	156	222	130	200	150	296
—	121	—	—	—	—	40	77
—	—	—	—	—	—	20	—
—	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—
—	121	—	—	—	—	60	77
148	433	156	222	130	200	210	373
816	425	1 400	381	2 100	3 340	2 280	2 325
200	121	200	190	300	61	60	310
—	303	116	318	100	49	250	245
7 532	11 762	8 156	11 726	10 714	29 611	11 752	12 668
8	11	8	23	4	30	2	28
2	80	—	10	—	33	10	39
—	10	—	10	—	29	10	—
2	23	2	4	—	12	—	3
6	16	6	17	8	7	—	9
372	263	100	380	—	740	130	182
7 922	12 165	8 272	12 170	10 726	30 462	11 904	12 929

TABLE IV.

Zooplankton collected with Clarke's plankton sampler, and with Nansen closing net,

Depth, meters	1	10	25	50	100	150
Volumes filtered, liters	2 784	2 112	1 832	1 248	384	564
Species / Gear	PS 8	PS 8	PS 8	PS 8	PS 8	PS 8
Calanus finmarchicus:						
♂	—	—	—	—	—	—
♀	9	32	9	53	—	—
V	—	9	—	2	—	—
IV	27	71	41	24	5	2
III	270	190	218	11	8	4
II	720	712	850	—	31	11
I	648	1 900	2 190	8	39	12
Total copepodites and adults	1 674	2 914	3 308	98	83	29
N VI	2 548	331	1 800	96	42	23
N V	2 375	426	1 035	176	57	35
N IV	36	331	3 050	168	31	16
N III	1 548	95	600	32	16	5
N II—I	—	—	—	—	—	—
Eggs	4	237	—	24	—	—
Total nauplii and eggs	6 511	1 420	6 485	496	146	79
Total *Calanus finmarchicus*	8 185	4 334	9 793	594	229	108
Calanus hyperboreus:						
♀	—	—	1	1	—	—
V	—	2	—	10	—	—
IV	1	12	14	19	5	4
III	—	—	—	—	3	—
II	18	118	55	—	—	—
I	72	142	164	—	—	—
Total copepodites and adults	91	274	234	30	8	4
N VI	180	47	272	—	—	—
N V	288	47	—	8	—	—
N IV	36	—	55	11	—	—
N III	36	—	—	—	—	—
Total nauplii	540	94	327	19	—	—
Total *Calanus hyperboreus*	631	368	561	49	8	4
Metridia copepodites and adults	—	—	—	19	5	—
Metridia nauplii and eggs	—	—	—,	192	34	5
Oithona spp. adults and larvae	—	—	546	259	16	4
Other copepods	3	154	102	43	104	30
Total copepods	8 819	4 856	11 002	1 156	396	151
Decapod larvae	—	1	2	—	—	—
Euphausiid calyptopis	—	9	300	22	3	4
E. nauplii and eggs	—	4	218	36	—	—
Fish larvae	—	3	43	1	—	—
Fish eggs	8	5	3	—	—	—
Other organisms	308	620	1 008	137	3	9
Total organisms	9 135	5 498	12 576	1 352	402	164

silk No. 8. Økssund, May 3. 1947. Number of organisms per 1000 liters of sea water.

425	25—0		50—25		100—50		150—100		425—150	
828	2 120		944		940		864		2 136	
PS 8	PS 8	8/72	PS 8	8/72	PS 8	8/72	PS 8	8/72	PS 8	8/72
—	—	—	—	—	—	1	—	1	—	—
1	11	33	47	50	13	34	—	12	—	35
—	4	950	11	8	—	2	—	—	—	5
1	47	500	26	308	3	7	1	—	—	—
4	306	6 900	53	650	21	—	4	35	—	50
13	1 840	7 500	26	700	21	130	19	80	—	—
6	1 980	5 300	143	500	59	20	22	10	4	—
25	4 188	21 183	306	2 216	117	194	46	138	4	90
11	1 103	1 700	774	1 600	43	—	35	—	5	—
11	603	2 400	1 620	1 600	64	—	15	10	6	—
—	1 558	1 700	1 920	1 000	64	—	27	10	9	—
—	850	700	402	400	—	10	28	—	2	—
—	—	—	11	—	—	—	—	—	—	—
—	189	400	42	—	43	50	17	5	—	—
22	4 303	6 900	4 769	4 600	214	60	122	25	22	—
47	8 491	28 083	5 075	6 816	331	254	168	163	26	90
1	—	1	—	—	—	—	—	—	0.5	135
1	5	5	6	10	9	4	1	20	1	205
2	10	16	37	58	16	8	—	30	0.5	50
—	—	—	—	8	1	2	—	1	—	10
1	47	200	—	—	—	—	—	—	—	—
2	47	200	11	—	—	—	—	—	—	—
7	109	422	54	76	26	14	1	51	2	400
—	94	500	—	—	—	—	—	—	—	—
—	—	—	11	—	—	—	—	—	—	—
—	—	—	42	—	—	—	—	—	—	—
—	—	—	—	—	—	—	—	—	—	—
—	94	500	53	—	—	—	—	—	—	—
7	203	922	107	76	26	14	1	51	2	400
34	—	—	21	—	12	17	7	12	15	457
10	47	—	148	100	11	80	23	10	—	120
—	94	17	435	100	133	80	9	10	2	—
39	142	—	44	256	38	277	133	251	37	839
141	8 977	29 022	3 830	7 348	551	722	341	497	82	1 906
—	1	1	1	3	—	—	1	—	—	7
1	—	350	38	16	3	30	—	30	1	—
2	—	150	96	16	27	30	1	—	1	20
—	7	15	20	2	—	3	2	1	—	2
—	12	9	—	—	11	—	5	—	—	—
14	578	1 417	678	301	145	115	14	27	17	603
155	9 575	30 964	6 663	7 686	737	900	364	555	101	2 538

TABLE V.

Percentage distribution of the different stages of *Calanus finmarchicus* in hauls with the plankton sampler (PS) and the Nansen net (Nn) in the Økssund. May 3. 1947. Silk No. 8.

Depth, meters	25—0		50—25		100—50		150—100	
Gear	PS	Nn	PS	Nn	PS	Nn	PS	Nn
♀	0.1	0.1	0.9	0.7	3.9	13.8	—	7.2
V	0.4	3.4	0.2	0.1	—	0.8	—	—
IV	0.6	1.8	0.5	4.5	0.9	2.8	0.6	—
III	3.6	24.6	1.0	9.5	6.4	—	2.4	21.5
II	21.6	26.7	0.5	10.3	6.4	51.2	11.3	49.0
I	23.2	18.9	2.8	7.3	17.8	7.8	13.1	6.1
Percentage of adults and copepodites	49.5	75.5	5.9	32.4	18.4	76.4	27.4	83.8
N VI	12.9	6.5	15.3	23.5	13.0	—	20.8	—
N V	7.1	8.5	31.9	23.5	19.3	—	8.9	6.1
N IV	18.3	6.1	37.8	14.7	19.3	—	16.1	6.1
N III	10.0	2.5	7.9	5.9	—	3.9	17.3	—
N I—II	—	—	0.2	—	—	—	—	—
Eggs	2.2	1.4	0.8	—	—	19.7	10.1	3.1
Total number of[1] *C. finmarchicus*	8 525	28 083	5 075	6 816	331	254	168	163

[1] In the PS hauls per 1000 liters of water.